

WHAT IS CLAIMED IS:

1. A method for embedding data in an input digital medium, comprising the steps of:

5 (a) generating a set of multi-level screens, each multi-level screen being generated by selecting a set of colors that comprise the colors that can be output by that multi-level screen;

(b) screening the input digital medium with the generated multi-level screens using a dither matrix and a set of level matrices; and

10 (c) selecting, for each of select number of pixel locations in the input digital medium, one of the level matrices, based on a message symbol to be embedded at that pixel location, to create an output, thereby embedding data in the input digital medium.

2. A method as recited in claim 1, wherein the multi-level screen is generated such that, for a single color, c_m color levels are selected to form an ordered set such
15 that $c_m < c_{m+1}$.

3. A method as recited in claim 2, wherein the generating of each multi-level screen in the set comprises determining an output color corresponding to an input color c at a given pixel location in the input digital medium by:

finding an index r such that $c_r \leq c \leq c_{r+1}$; and

20 performing one of the following steps:

outputting c_0 , if $c \leq c_0$;

outputting c_{M-1} , if $c \geq c_{M-1}$; or

computing $t = (c - c_r) / (c_{r+1} - c_r)$, if $c_0 < c < c_{M-1}$, and determining if

$t < d_{u \bmod P, v \bmod Q}$, and

25 outputting c_r , if $t < d_{u \bmod P, v \bmod Q}$, or

outputting c_{r+1} , if $t \geq d_{u \bmod P, v \bmod Q}$

wherein M represents the number of levels of that multi-level screen, $D = [d_{ij}]$ denotes the dither matrix and $P \times Q$ defines its size, and (u, v) identifies a location in the input digital medium.

5 4. A method as recited in claim 1, wherein, for each selected pixel location in the input digital medium, the level matrix used to create the corresponding output is selected independently or as a function of the neighboring input and output colors.

5. An apparatus for embedding data in an input digital medium, the apparatus comprising:

10 means for generating a set of multi-level screens, each multi-level screen being generated by selecting a set of colors that comprise the colors that can be output by that multi-level screen;

 means for screening the input digital medium with the generated multi-level screens using a dither matrix and a set of level matrices; and

15 means for selecting, for each of select number of pixel locations in the input digital medium, one of the level matrices, based on a message symbol to be embedded at that pixel location, to create an output, thereby embedding data in the input digital medium.

20 6. The apparatus of claim 5, wherein the apparatus comprises a computer, printer, or photocopier.

7. A machine-readable medium having a program of instructions for directing a machine to embed data in an input digital medium, the program of instructions comprising:

25 (a) instructions for generating a set of multi-level screens, each multi-level screen being generated by selecting a set of colors that comprise the colors that can be output by that multi-level screen;

(b) instructions for screening the input digital medium with the generated multi-level screens using a dither matrix and a set of level matrices; and

(c) instructions for selecting, for each of select number of pixel locations in the input digital medium, one of the level matrices, based on a message symbol to be embedded at that pixel location, to create an output, thereby embedding data in the input digital medium.

8. A machine-readable medium as recited in claim 7, wherein the multi-level screen is generated such that, for a single color, c_m color levels are selected to form an ordered set such that $c_m < c_{m+1}$.

9. A machine-readable medium as recited in claim 8, wherein the instructions for generating each multi-level screen in the set comprises instructions for determining an output color corresponding to an input color c at a given pixel location in the input digital medium by:

finding an index r such that $c_r \leq c \leq c_{r+1}$; and

performing one of the following steps:

outputting c_0 , if $c \leq c_0$;

outputting c_{M-1} , if $c \geq c_{M-1}$; or

computing $t = (c - c_r) / (c_{r+1} - c_r)$, if $c_0 < c < c_{M-1}$, and determining if

$t < d_{u \bmod P, v \bmod Q}$, and

outputting c_r , if $t < d_{u \bmod P, v \bmod Q}$, or

outputting c_{r+1} , if $t \geq d_{u \bmod P, v \bmod Q}$

wherein M represents the number of levels of that multi-level screen, $D = [d_{ij}]$ denotes the dither matrix and $P \times Q$ defines its size, and (u, v) identifies a location in the input digital medium.

10. A machine-readable medium as recited in claim 7, wherein, for each selected pixel location in the input digital medium, the level matrix used to create the corresponding output is selected independently or as a function of the neighboring input and output colors.